REMARKS

In the amendments above, Claim 49 has been cancelled, Claims 11-13, 19, 25, 31, 35, 39, 62-64, and 67 have been amended, and new Claims 68 and 69 have been added, to more particularly point out and distinctly claim Applicants' invention.

Claims 5-33, 35-40, 49, and 62-67 have been rejected under 35 U.S.C. §112, second paragraph. The Examiner's attention is directed to the amendments to the claims above, which are believed to overcome this rejection.

Claims 41-45 have been rejected under 35 U.S.C. §102(b) as being anticipated by Pless et al., U.S. Patent No. 5,456,706 ("Pless"). The Examiner maintains that Pless is capable of meeting the functional use recitations presented in the claims.

Claims 41-45 have been rejected under 35 U.S.C. §102(b) as being anticipated by Hoffmann et al., U.S. Patent No. (5,534,022) ("Hoffman"). The Examiner maintains that Hoffmann is capable of meeting the functional use recitations presented in the claims.

Claims 11, 28, 35-45, 49, and 62 have been rejected under 35 U.S.C. §102(b) as being clearly anticipated by Kieval U.S. Patent No. 5,814,079 ("Kieval").

Claims 11, 35-45, 49, and 62 have been rejected under 35 U.S.C. §102(b) as being anticipated by Noren et al., U.S. Patent No. 5,649,966 ("Noren"). The Examiner maintains that it is inherent that Noren contains some type of connection means for connecting the electrodes to the controls means; that such connection being a connector, a conductor, and/or the lead itself; and that, in addition, Noren is capable of performing the functional use recitations presented in the claims.

Claims 11, 35-45, 49, and 62 have been rejected under 35 U.S.C. §102(b) as being anticipated by or, in the alternative, under U.S.C. §103(a) as obvious over Scherlag, U.S. Patent No. 5,083,564 ("Scherlag"). The Examiner maintains that Scherlag uses conventional leads with an electrode separation being one mm to ten mm; that, in addition, Scherlag states that the system can be incorporated into an implantable system with sensing and delivering of the pulses and will inherently have a control means to control the stimulation; that, in addition, Scherlag inherently contains connection means to connect the electrodes to the control means, such connection being a connector, a conductor, and/or the lead itself; and that Scherlag is capable of performing the functional use recitations presented in the claims.

The Examiner also maintains that, in the alternative, Scherlag discloses the claimed invention except for the control means to receive the signals and determine the parameters of the electric field and deliver the field to the electrodes; and that it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the implantable stimulator as taught by Scherlag, with the control means to receive the signals and determine the parameters of the electric field and deliver the field to the electrodes to provide an automated system that controls the device to sense heart signals, determine electric pulse parameters, and deliver the pulses to the electrodes that does not require constant intervention from a physician.

Claims 5-10, 12-32, and 63-67 have been rejected under 35 U.S.C. §103(a) as being unpatentable over Noren (or Scherlag or Kieval). The Examiner maintains that Noren (or Scherlag or Kieval) discloses the claimed invention except for the specifics of the lead/electrodes, such as the lead being a single lead having two pairs of electrodes, minimizing the diameter larger than a distal portion of the lead and longitudinal length less that the external diameter (less than 1.2 mm), the electrode materials having suitable biostable and biocompatible characteristics, a delivery electrode wound in parallel to a spiral coil-like form having an external diameter larger than a distal diameter, the spiral

coil form having a longitudinal length, 20 mm, substantially greater than the external diameter and an effective surface area of about 30-250 square mm, electrodes spaced to occupy 20-150 mm, conductors and suitable connectors for each electrode an ISI connector, ogival intrusion head and a length of suitable tubing with a bend at about 45 degrees, means to introduce the lead, and a diameter to allow the lead to pass through a lumen of less than about 1.5 mm, and that it would have been obvious to one having or ordinary skill in the art at the time the invention was made to modify the lead and electrodes as taught by Noren (or Scherlag or Kieval), with the specifics of the lead/electrodes recited above, since it was known in the art that leads/electrodes incorporate the specifics of the lead/electrodes recited above, to provide implantable, biocompatible leads and electrodes that can be easily placed and maintained in the heart to deliver electrical therapy to the heart and sense electrical signals from the heart.

The Examiner also maintains that Noren (or Scherlag or Kieval) discloses the claimed invention except for the diameter being less than 1.2 mm or the electrode impedance being between 50 and 500 Ohms (Claims 14 and 18), and that it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the lead having electrodes as taught by Noren (or Scherlag or Kieval), with the lead diameter being less than 1.2 mm and the electrode impedance being between 50 and 500 Ohms since it was known in the art that leads having electrodes use a lead diameter less than 1.2 mm to allow the lead to have a small footprint n the body and/or to allow the lead to be placed in the coronary veins and since it was known in the art that leads having electrodes provide the electrode with an impedance between about 50 to about 500 Ohms to provide a low impedance lead will not waste energy of the implantable device.

The Examiner further maintains Noren (or Scherlag or Kieval) discloses the Claimed invention except for the multiple lumens each having a conductor (Claim 22), the particulars of the distal connector means comprising a substantially flat terminal member (Claim 23), connecting the conductors to the distal connector using laser welding or crimping (Claims 24 and 25), the terminal member being titanium (Claim 26), and spiraling of the conductors in the lead lumen (Claim 27) are that it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the lead having electrodes as taught Noren (or Scherlag or Kieval), with the lead having multiple lumens with each lumen having a conductor, connection of the conductors to distal connectors using laser welding or crimping, and the spiral conductors in the lumens since it was known in the art that leads having electrodes use; multiple lumens, with each lumen having a conductor in the lumen to allow the lead body to have a smaller footprint in the body by not using insulation on each conductor; laser welding or crimping to connect conductors to distal connectors to provide a fast, secure method for the connection of different elements; and to spiral the conductor in the lumen to allow the lead to be more flexible and less resistant to breakage.

In addition, the Examiner maintains that it would have been an obvious matter of design choice to a person of ordinary skill in the art to modify the lead having electrodes as taught by Noren (or Scherlag or Kieval) with the particulars of the distal connector means comprising a flat terminal member and the terminal member being titanium, because Applicants have not disclosed that the particulars of the distal connector means comprising a flat terminal member and the terminal member being titanium provides an advantage, is used for a particular purpose, or solves a stated problem; that or ordinary skill in the art, furthermore, would have expected Applicants' invention to perform equally well with the connections of the conductors to the connectors as taught by Noren (or Scherlag or Kieval), because it provides a secure connection of the conductors to the connectors and allows sensing or applying a field to take place; and that, therefore, it

would have been an obvious matter of design choice to modify Noren (or Scherlag or Kieval) to obtain the invention as specified in the Claim(s).

Applicants respectfully traverse the above rejections.

The present invention is in the field of leads comprising electrodes that are implanted to provide long-term therapeutic care – a field that appears to be very crowded with devices having similar appearance and function to those of the present invention. The principal distinguishing feature of the device of the present invention is in the type of electric field (i.e., the amount of energy) supplied to the surrounding tissue by the electrodes. It is to be borne in mind throughout the discussion of the relationship of this invention to the prior art that, until the work by the Assignee of the present application described in the references cited below, this energy range was not felt to be useful therapeutically by those skilled in the art, and, therefore, no leads designed to deliver signals in this energy range have been previously described. For this reason alone, any apparatus designed and optimized to supply therapeutic signals having energy in this range is by definition new and inventive. Beyond this fact however, the development of the device of the present invention involved much more than simple straightforward adaptation of presently available devices to the new energy range. A great deal of innovative skill was necessary to balance and optimize the many different and often conflicting demands and factors. Amongst these factors are the selection of the materials, electro-chemical properties, and dimensions of the electrodes as well as requirements and limitations imposed by the intended operating environment of the device as a whole, e.g. dimensions, flexibility, biocompatibility, energy supply, etc. As a specific example of the many difficulties overcome in inventing the device, a discussion of the principle considerations that were taken into account in determining the appropriate size for the delivery electrodes is given below.

The invention, as presently defined in the amended Claims, is directed to a lead designed to perform both localized sensing and to provide localized therapy based on the results of the return signals from the sensing electrode means.

In the preferred embodiments, the therapy is provided by delivery electrode means that are capable of enabling non-excitatory stimulation of a portion of tissue, such as for example the heart muscle, in response to the results of monitoring or sensing of the activity in essentially the same portion of tissue using the same or other electrodes. In other words, the present invention provides a method and system for the precise delivery of non-excitatory electrical signals to one or a plurality of locations on the cardiac muscle, for example, each of which is synchronized, to the locally sensed intrinsic electrical activity (page 4, lines 19-21).

Other characteristics of the lead of the invention are that it is designed for chronic implantation (pg. 7, line 15), it can be introduced into the left side of the heart through the Coronary Sinus (Fig. 19 and description on pg. 32 also pg. 37, middle paragraph), and its delivery electrodes can produce a pacing or defibrillation stimulus in addition to non-excitatory signals (pg. 31, lines 19-23).

Non-excitatory stimulation of a tissue such as the heart is very different from both pacemaker operation and from defibrillator operation, as clearly shown in WO 97/25098, which was incorporated in the present application (page 2, line 1) by reference thereto. Thus, as described on page 8, line 37, to page 9, line 7, of this reference:

"A pacemaker exerts excitatory electric fields over many cycles, while a defibrillator does not repeat its applied electric field for many cycles, due to the disruptive effect on the defibrillation current on cardiac contraction. In fact, the main effect of the defibrillation current is to reset the synchronization of the heart by forcing a significant percentage of the cardiac tissue into a refractory state. Also, defibrillation currents are several orders of magnitude stronger than pacing currents." (Emphasis added.)

In contrast thereto, in non-excitatory stimulation, "the regular activation of the heart is not disrupted, rather, the activation of the heart is controlled, over a substantial number of cycles, by varying parameters of the reactivity of segments of cardiac muscles cells".

Further, and as described in WO 97/25098, page 9, line 37, to page 10, line 2:

"A non-excitatory signal may cause an existing action potential to change, but it will not cause a propagating action potential, such as those induced by pacemakers. The changes in the action potential may include extension of the plateau duration, extension of the refractory period, shortening of the post-plateau repolarization and other changes in the morphology of the action potential." (Emphasis added.)

Further examples of non-excitatory stimulation are provided in the reference in succeeding sections thereof.

Thus, non-excitatory stimulation is different in purpose and function from either pacing or defibrillation. As described in page 4, line 22, to page 5, line 2, of the present application, "the timing and characteristics of an electrical field that modifies the contractility of the heart and the sensing required for controlling the delivery of the signal required, are entirely different from any signal applied to the heart for pacing or defibrillating." (Emphasis added.)

In addition to defining non-excitatory signals by the physiological effects such signals produce in tissue, such signals can be described quantitatively in terms of the amount of energy that must be supplied by the delivery electrode means. As described in the present application, in the above referenced PCT publication, and is well known to persons skilled in the art, pacing signals have a relatively low energy, defibrillation signals are on the order of magnitude of 10^5 times greater than pacing signals, and non-excitatory signals typically have an energy on the order of 20-100 times that of pacing signals.

In one embodiment of the invention, the same electrode (a unitary electrode) is used for sensing and for providing the appropriate non-excitatory electric field, the sensing mode and the generation of the electric field being non-simultaneous. In another embodiment, one pair of electrodes in close proximity to each other is provided, one electrode for sensing, and the other for providing the electric field. In yet another embodiment, pairs of electrodes are provided, in each pair one electrode providing the sensing functions in close proximity to the other electrode, which is for providing the non-excitatory electric field. In each case sensing and the generation of an appropriate electrical field are carried out at either the same location or in close proximity, and when there are a plurality of electrodes for sensing and/or providing a field along the lead, these are substantially independent one from the other so that different electric fields may be provided at different locations along the lead. Thus, a lead according to the present invention is adapted for selectively delivering a suitable non-excitatory electric field to at least portion of tissue to achieve a desired change by enabling the sensing and field generation to be performed at the same or very close locations on the lead, and where applicable by enabling different electric fields to be selectively provided by each corresponding electrode.

The size of the electrodes is one of the critical design features of the invention. To sense the activity at a well-defined localized area, the sensing electrodes must be very small. On the other hand, delivery of signals large enough to produce the desired therapeutic results requires much larger electrodes. For this reason, separate sensing and delivery electrodes are used in most embodiments of the present invention.

The size of the delivery electrode influences the final performance in at least three ways that had to be considered when designing the delivery electrodes of the lead of the invention. Firstly, to insure sufficient robustness to allow for long-term implantation of the electrode, the magnitude of the applied energy and duty cycle must be taken into account when determining the size of the delivery electrode. When an electrode is implanted and activated, a capacitance is created between the electrode and the surrounding tissue. The capacitance depends on the area of the electrode facing the tissue and the material properties of the electrodes and the surrounding electrolyte. If the capacitance rises above a critical value, irreversible electro-chemical processes leading to deterioration of the electrode and electrolysis of the electrolyte takes place. One guiding design principle is that the larger the area of the electrodes, the lower the risk that the critical value will be reached. One of the most important of the material properties of the electrodes affecting the capacitance is the amount of charge per surface area of the electrode, the higher the value of this parameter, the higher the capacitance. The second consideration is that the size of the delivery electrode must be small enough to deliver a signal to the surrounding tissue of sufficient energy density to produce the desired effect. If the area of the electrode is too large, it might never be possible to achieve high enough current densities to produce the desired therapeutic results without using an unacceptably high level of input energy (in which case the energy source (battery) would have an unacceptably short lifetime making the device as a whole unsuited for long-term implantation). Thirdly, the size of the electrode determines the size of the area and the location at which the signal can be applied. A large electrode will not allow localized

therapy and a small electrode will not allow therapies that must be applied simultaneously to large areas of tissue. A large electrode cannot be incorporated into a lead or other delivery means that must be narrow enough and flexible enough to deliver the lead to a location in a narrow lumen or must travel through a narrow, twisted path to get to the implantation site.

In summary, it can be seen that the design of delivery electrodes that are suitable for meeting the requirements of the present invention is a very complex task. On the one hand, the electrodes should be relatively large to allow for long term application of non-excitatory signals without deterioration and on the other hand they must be small enough to allow localized application of the non-excitatory signal, to enable the lead carrying them to be introduced into the left ventricle by passing through the coronary sinus, and to provide a high enough current density.

From the above, it also can be seen why prior art pacing and defibrillation electrodes are not capable of satisfying the requirements of the present invention. Pacing electrodes are smaller than the delivery electrodes of the invention and deliver a smaller signal. If higher energy is applied to such electrodes to produce non-excitatory signals, then rapid deterioration of the electrode will take place, making it unsuitable for long-term implantation. For this reason, prior art pacing electrodes can not be used to produce the same results as the delivery electrodes of the invention. Defibrillation electrodes are relatively large making them unsuitable for passage through the coronary sinus for insertion in the left ventricle. They also cannot be used to apply a localized signal. More significantly, the large surface area of these electrodes means that a high enough current density cannot be attained to produce non-excitatory signals for a protracted period of time without depleting the energy source of the device. For this reason, prior art defibrillation electrodes can not be used to produce the same results as the delivery electrodes of the invention.

The claims herein are not disclosed or suggested by the references cited by the Examiner. More particularly, Kieval illustrates the point that Applicants attempted to make in the previous response, i.e., that the difference in the strength of the signals to be produced is the factor that above all determines the design of the electrodes and the leads that carry them. The lead described by Kieval is intended to deliver cardioverter-defibrillator (CD) signals. The large energy requirement requires that Kieval's lead use relatively large heavy duty electrodes in order to be able to deliver the required signals for a sustained period of time. Kievel does not supply many details of the design parameters but does state in Col. 10, line 1, that the electrode is on the order of 5 cm length for his RV lead; in Col 10, line 15, 5 cm for a coronary sinus lead; in Col.10, line 38 Kievel describes a 10 cm or longer electrode; and in Col.11, lines 11 to 21, Kievel states that it is preferable to use large surface area electrodes to deliver AS pulses and specifically refers to the CD electrode for this purpose. Because of the size of these electrodes relative to the size of the heart chambers and the vessels, such as the CS, in which Kievel states that he applies the signals, he can only place a single delivery electrode on his lead and in fact he neither describes nor suggests the possibility of having a bipolar lead to deliver his CD or AS signals.

In contrast, the electrodes of the present invention are designed to chronically deliver non-excitatory signals that are significantly smaller than CD signals. This has allowed the Applicants to provide smaller electrodes and a smaller dimension lead that can comprise more than one delivery electrode (Claimed in Claim 62). Each of the delivery electrodes can have a length of between about 5 mm and 40 mm claimed in Claim 16), is thin enough and flexible enough to pass through the coronary sinus or other small lumen (claimed in Claims 14, 67, and 68), and is capable of delivering the required non-excitatory signals for extended periods of time (claimed in Claim 62).

Noren is concerned with supplying signals to stop fibrillation and tachycardia but the main use of the apparatus appears to be for diagnostic purposes and as such is most probably not designed for chronic use. The publication supplies no details of how the signal delivery apparatus is built, or specification of dimensions, materials, etc., of the components, or of the energy levels of the signals, and therefore this reference does not anticipate the present invention in any significant way.

Scherlag describes commercially available electrode catheters designed for chronic pacing. As discussed in Applicants' response to the previous Office Action, such electrodes are not designed for providing the non-excitatory signals of the present invention for prolonged periods of time because of the potential deterioration of the electrodes that result from the relatively much higher energy of the non-excitatory signals compared the pacing ones. Scherlag does not teach any specific characteristic of a lead and therefore does not anticipate the present invention.

With regard to specific comments made by the Examiner, Applicants wish to point out that with regard to the "localized signals", Claim 62 states that each delivery electrode has associated with it at least one sensing electrode located "in close proximity". On page 7, lines 19-21 of the application the term "close proximity" is defined to mean "that the electrodes are positioned at a short distance from one another, e.g. up to about 10 mm." Thus the fact that each delivery electrode delivers a non-excitatory signal whose characteristics depend on the characteristics of the signals sensed by its associated sensing electrode means that the applied signal is applied no more than 10 mm of the location of the sensing electrode and not in response to some parameter measured at a distance greater than 10 mm from the location of the delivery electrode. This characteristic of the present invention is mentioned repeatedly in the specification and has been emphasized by the amendment to independent Claim 62.

With regard to the "amount of time the device operates", as stated on page 7, line 15, of the application and now in amended Claim 62, the device is a lead for chronic use, i.e., long duration use.

The Examiner suggested that the rejection to the specifics of the lead might be overcome by incorporating them into new claims that contain control means. Applicants respectfully suggest that since independent Claim 62 contains control means and that the other claims are all dependent on Claim 62, the essence of the Examiner's suggestion has already been fulfilled.

Applicants wish to again stress that the novelty and inventiveness of the present invention lies in the special design features of the lead of the invention that are first and foremost dictated by the energy level of the signals generated by the device. Signals of the type generated by the lead of the invention are not encountered in any of the cited prior art, and, therefore, the design parameters of the prior art devices differ - in most cases significantly - from those of the prior art.

Applicants would also like to point out to the Examiner that the present application contains considerable detail about materials, dimensions, electrical properties such as capacitance, etc., that would allow the skilled person to produce the lead of the invention. Such details are missing in the majority of the cited prior art publications, and it is not clear how one could construct the devices described therein, much less employ the teachings of these publications to construct the lead of the invention.

In view of all of the above, and especially taking into account the fact that the present invention is directed to providing for the first time an apparatus that is uniquely able to provide a new type of therapeutic signal for modifying the activity of a tissue, Applicants respectfully request that the Examiner review the amendments above and the comments above and then reconsider the bases of the rejections under §§ 102(b), 102(e), and 103(a). It is earnestly believed that these rejections have been overcome and should be withdrawn.

Reconsideration and allowance of all the Claims herein are respectfully requested.

Respectfully submitted,

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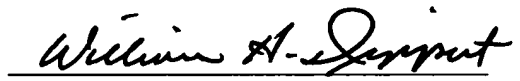

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